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(54) **Vacuum control valve**

(57) An automatic valve for use in a vacuum belt conveyor 22 comprises a valve chamber (80) having a first opening (25) to the atmosphere and a second opening (81) for connection to a source of reduced pressure and defining a valve seat (84) in the valve chamber. A valve member (82) seats against the valve seat (84) so as to form an imperfect seal and is biassed away from the valve seat, the arrangement being such that when a reduced pressure is applied through the second opening (81) the valve member (82) will seat against the valve seat if the first opening (25) is unobstructed and be biassed to its open position due to leakage past the valve member when the first opening (25) is obstructed, e.g. by a document on the conveyor.

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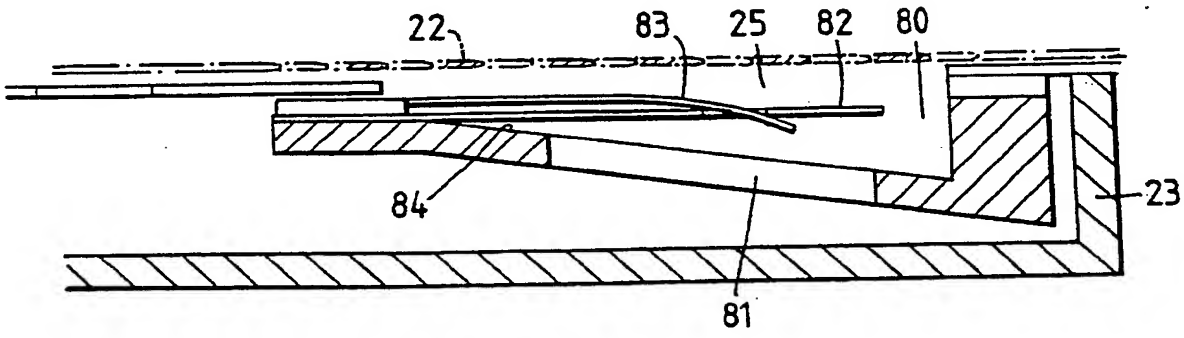
Fig.3.



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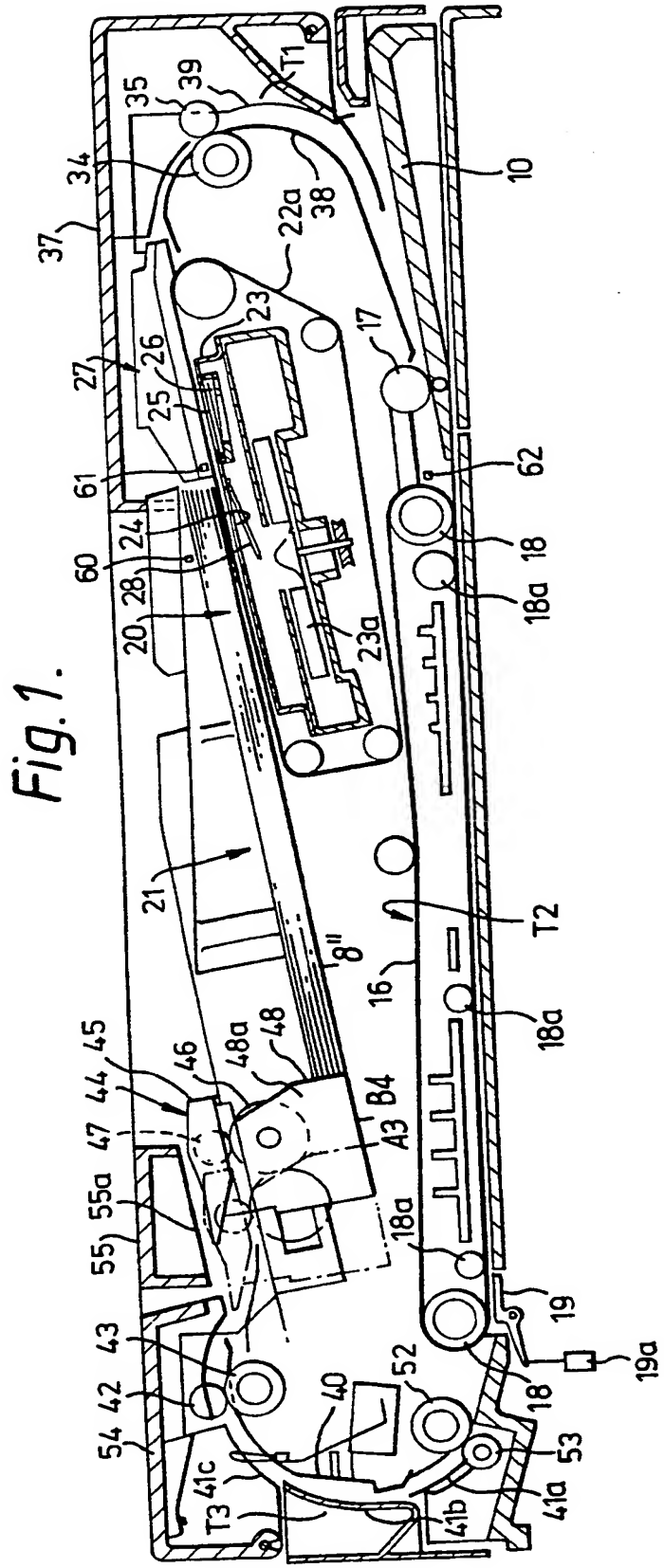


Fig. 1.

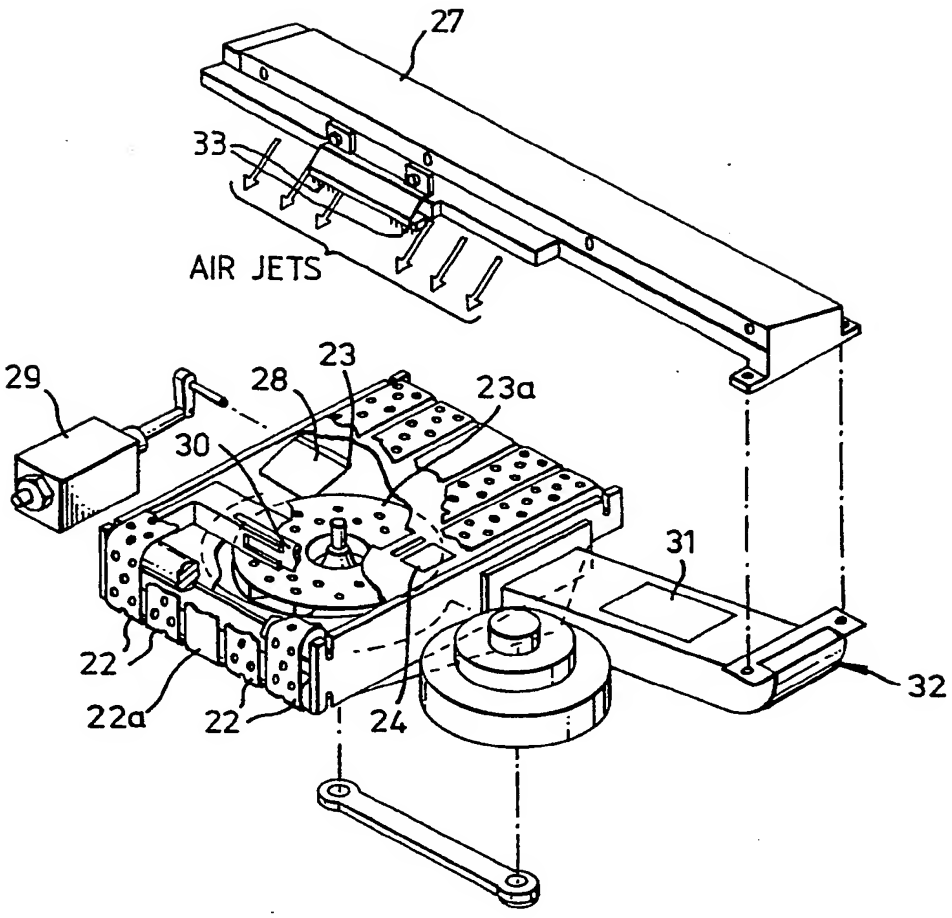


Fig.2.

Fig.3.

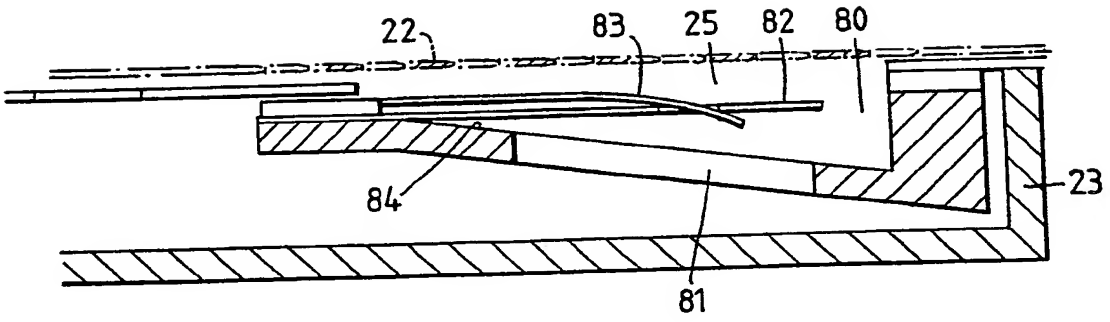


Fig.4.

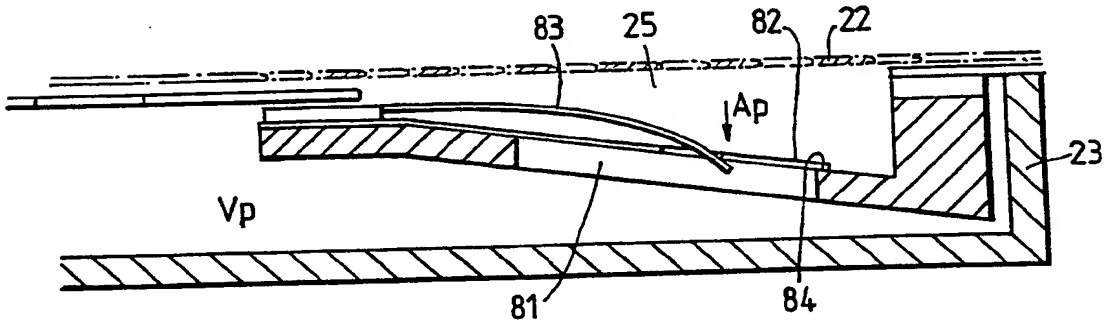


Fig.5.

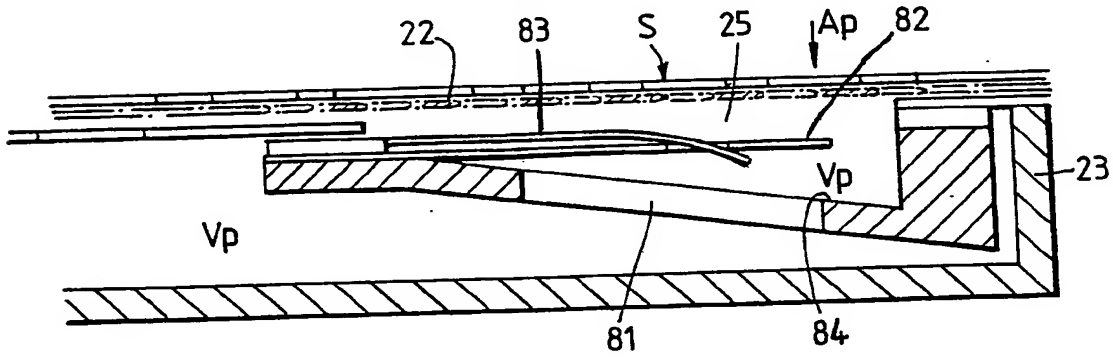


Fig.6.

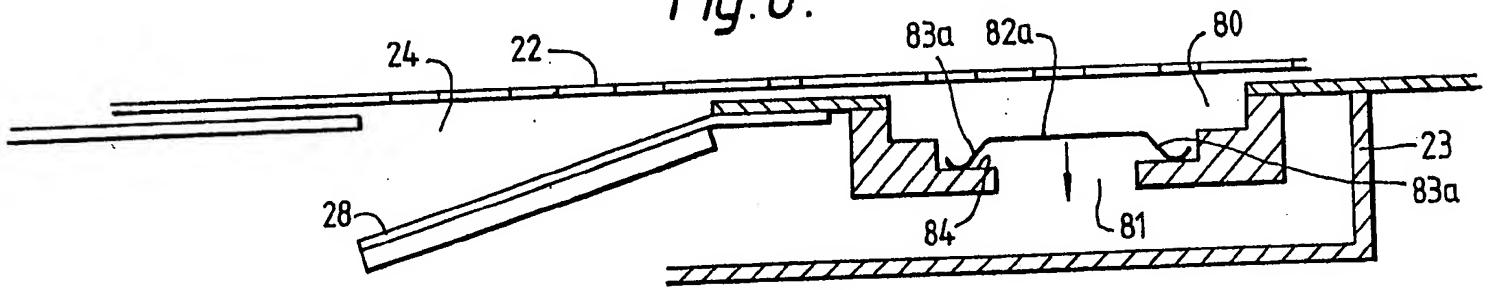


Fig.8.

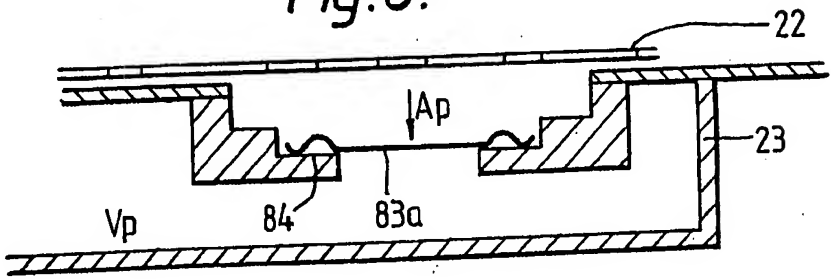


Fig.7.

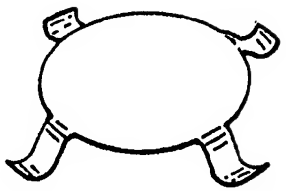
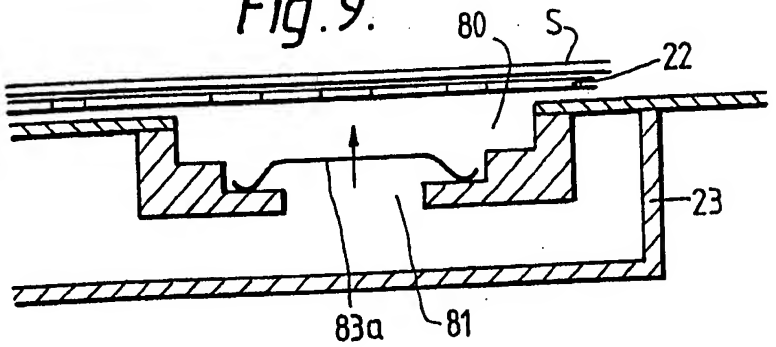


Fig.9.



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SPECIFICATION

Automatic valves and vacuum belt conveyors incorporating same

This invention relates to automatic valves, particularly for use in vacuum belt conveyors, and to vacuum belt conveyors for sheets incorporating same.

Vacuum belt conveyors for sheets are widely used both for transporting sheets and for feeding sheets from a stack. Such conveyors generally comprises one or more air-pervious endless conveyor belts, which may be formaninous or perforate, which are driven across vacuum means including a plurality of vacuum ports which apply a negative pressure at the back of the belt(s) to hold sheets being conveyed against the belt.

One of the problems associated with such conveyors is that the vacuum (negative pressure) source must be capable of creating a suction pressure when only some or perhaps even none of the vacuum ports are obstructed by sheet being fed and this requirement means that the vacuum source must be capable of coping with a larger volume of air.

It is an object of the present invention to reduce this requirement and to this end a vacuum belt conveyor according to the invention is characterised in that the vacuum means includes at least one valve connected between at least one of said ports and a source of negative pressure and adapted automatically to close only when said port is not obstructed and said negative pressure source is operating.

With such an arrangement the volume of air which has to be displaced when some or all of the vacuum ports are unobstructed may be considerably reduced. One or more valves may be utilised and the or each valve may be associated with one or a group of vacuum ports. Such groups may extend transversely across the conveyor or lengthwise, or both. Thus, in a vacuum belt transport for transporting individual sheets from one location to another, in which there is a plurality of side-by-side endless belts extending across a vacuum box having a row of ports underneath each belt, a valve may for example be associated with each trasverse row of ports or two or three of such rows. It is also contemplated that one or more ports may be controlled by an automatic valve as proposed above while another port or ports is operable independently of the presence or absence of a sheet over the port(s). Thus, in a sheet feeder for feeding sheets from the bottom of a stack, one port or transverse row of ports is arranged beneath the forward end of a stack of sheets and is controlled by an externally operated, e.g. solenoid-operated, valve for acquiring the bottom sheet in the stack and a second port or row of ports is controlled by an automatic valve in accordance with the invention is arranged ahead of the stack to advance a sheet forwarded to it from the stack.

An automatic valve according to this invention suitable for use in such a vacuum belt conveyor comprises an automatic valve comprising a valve chamber having a first opening to the atmosphere and a second opening for connection to a source of reduced pressure and defining a valve seat in the valve chamber, characterised by a valve member adapted to seat against the valve seat so as to form an imperfect seal and biassed away from the valve seat, the arrangement being such that when a reduced pressure is applied through the second opening the valve member will seat against the valve seat if the first opening is unobstructed and be biassed to its open position due to leakage past the valve member when the second opening is obstructed. While particularly suitable for use in a vacuum belt conveyor it will be understood that an automatic valve according to the invention may have other uses.

In one preferred embodiment of automatic valve according to the invention the valve member comprises a sealing flap secured at one end for movement into and out of engagement with the valve seat and a spring flap secured at one end adjacent the sealing flap and having its free end connected to the sealing flap near the free end thereof. In another embodiment the valve member comprises a sheet of resilient material having integral collapsible feet.

In order that the invention may be more readily understood, reference will now be made to the accompanying drawings, in which:

Figure 1 shows a document handler for a copying machine incorporating a vacuum belt separator/feeder according to the invention;

Figure 2 is a perspective view showing the separator/feeder in greater detail;

Figure 3 is a scrap sectional view of the separator/feeder shown in Figure 1 showing an automatic valve according to the invention at rest.

Figure 4 is a view like that of Figure 3 showing the valve when negative pressure is applied in the absence of a sheet;

Figure 5 is a view like that of Figure 3 showing the valve when negative pressure is applied and a sheet is present;

Figure 6 shows a section through a second embodiment of automatic valve according to the invention at rest;

Figure 7 is a perspective view of the valve member showing it in greater detail;

Figure 8 is a view like that of Figure 6 showing the valve when negative pressure is applied in the absence of a sheet, and

Figure 9 is a view like that of Figure 6 showing the valve when negative pressure is applied and a sheet is present.

Referring to Figure 1 there is shown a recirculation document handler for feeding documents to be copied to a platen 3 of a photocopier. The document handler includes a storage tray 21 for the documents to be copied and document circulating means for delivering the documents in turn to the platen from the storage tray and for returning the documents to the tray, whereby the documents may be circulated and recirculated in sequence past the platen for repeated copying (precollation mode). The documents may either be transported across the platen at a constant velocity past a stationary optical system of the photocopier, or instead they may be reg-

istered on the platen prior to coying and the stationary document exposed by scanning optical system or flash exposure. For this purpose a registration member or gate 19, which can be moved in and out of sheet blocking position at the registration edge of the platen by means of a conventional solenoid type actuator 19a, is provided for registering the document in stationary position on the platen 3 while the optical system 4 is scanned across the document. When the document is registered on the platen, the document handler can be operated so-called stacks mode wherein each document is copied a plural number of times during a single delivery to the platen. In one form of the photocopier, as used herein, the optical system is capable of scanning across a stationary document on the platen while it can also be fixed in position for scanning a moving document advanced across the platen at a constant velocity.

The document handler comprises, in addition to the storage tray 21, a document separator/feeder 20, a pre-platen transport T1 for conveying documents to the platen, a platen transport T2 and a post-platen transport T3 by which documents are returned to the storage tray.

The document storage tray 21 is mounted over the platen 3 and suitably accommodates 50 documents between 8 inches × 10 inches and B4 in size. The tray slopes upwardly towards the separator/feedeer 20 at an angle of about 10°. Adjustment of the tray to accommodate different document sizes is as follows. An assembly 44 including a registration cross-beam 48a can be adjusted for paper from 8 inches wide to B4. (Document sheets are placed in the tray so as to be fed long edge first.) The position of the registration edge 48 in minimum (8 inch) and maximum (B4) set feeding locations is indicated.

The registration edge 48 is formed at the front of registration cross-beam 48a. It is formed by an adjustable corner piece (not shown), mounted on the cross-beam 48a, and which also determines side registration, and two registration pads (also not shown) on the cross beam 48a. A driven O-ring stack assist (not visible) positioned approximately in the centre of an A4 size sheet is also mounted on the cross-beam. The corner piece has a generally triangular floor extending between the walls; the front edge of the floor is cut away to accommodate the tray separator pocket (see below) in its position for minimum size documents. Adjustment is achieved by moving the whole assembly 44 on tracks mounted to the side frames and it is locked by a ratchet mechanism acting on a rack along the bottom of the tray. The moving force is provided by the operator who also adjusts the registration corner by sliding it along a friction guide on the front of the cross-beam 48a.

A set counter mechanism (not shown) is mounted on the cross-beam 48a and has a counter arm projecting through the beam so that it can overlie the document(s) in the tray. The arm is pivoted so that as the last document is fed it falls through a slot in the floor of the tray and actuates a sensor. The arm is then returned to the top of the document stack.

An input tray sensor 60 is located on the rear side frame near the lead edge of the tray to sense that there are documents present.

Sheet separation and acquisition is accomplished by a vacuum belt corrugation feeder (VCF) 20 (Figures 1 and 2) according to the invention using flotation pressure differences between the bottom sheet and the sheets above, sheet corrugation and vacuum. A parabolic contour pocket is cut out at the lead edge of the tray 21 and dished down 3mm in the manner shown and described in US Patent No. 4275877 issued June 30, 1981. Documents placed in the tray, bridge this gap and form a flotation pocket. Transport belts 22 surface through the document tray within the contour pocket. The transport system consists of five rubber vacuum belts 22, the centre belt 22a being raised 2mm above the four outer belts. This produces the corrugation when the document is pulled down by the vacuum. The frequency and size of the holes in the belts 22 regulates the volume of air that can be drawn through them. The transport belts 22 move across the top plate of a vacuum housing 23 which has open slots or vacuum ports 24 in its coincident with the perforations in the belts. Once again the frequency and size of these slots 24 regulates the volume of air that can be drawn into the vacuum chamber beneath. Set into the top plate is a 2mm high ramp which lifts the centre belt 22a to form the corrugation effect.

Document stack flotation is accomplished by a frontal assault of air from an air knife 27 (see Figure 2). The air jet impinges on the tray just in front of the lead edge of the document stack; this permits volumetric flow expansion of air within the pocket contour of the tray and also riffles the front edge of the documents to allow a differential pocket of air between the bottom sheet and sheet 2. This assists in the acquisition, separation and feeding of the bottom document.

The sidewalls of the document tray 21 are vented to allow air to escape and prevent arched inflation of the stack with its resultant multifeeds. The trail edge of the tray is also vented to improve sheet stability and turbulent lift of document trail edge.

Within the vacuum chamber 23 is housed a vacuum flap valve 28 which regulates the timing of the vacuum through the slots 24 in the top plate and belts and hence the acquistion timing of documents. The valve 28 is actuated by a shaft which passes through the side wall of the vacuum housing and is attached to a solenoid 29. A vacuum relief valve 30 is also positioned in one of the vacuum chamber side walls. It is actuated by the chamber pressure, and allows air to the air knife 27, when a document has been acquared by the vacuum transport and effectively closed off the inlet ports to the vacuum chamber 24.

Beneath the vacuum chamber is a scroll-shaped impeller housing containing an impeller 23a. Air drawn through the vacuum transport belts 22 and the vacuum chamber 23 is exhausted and ducted to the air knife 27 which is located above the lead edge of the document tray. A pressure relief valve 31 is situated in the duct 32 to control air knife pressure which would otherwise cause document 'blow

away' prior to the closed inlet port condition.

A second set of vacuum ports 25 (like the ports 24) is arranged beneath the belt 22 at the forward end of the housing 23 to form a take-away vacuum feed. The ports 25 are controlled by a flap valve 26 in accordance with the invention which operates automatically to take away documents which have been acquired at the ports 24 and advanced by the belts 22 over the ports 25. Once the sheet has been picked up by this vacuum feed the valve 28 is closed. Closure of the valve 28 is controlled by a vacuum timing sensor 61 which senses the lead edge of the document. The valve 26 is normally closed when the vacuum system is operating and is constructed to open automatically when the ports 25 are closed by the document arriving thereover.

As shown in Figure 3 the valve 26 includes a valve chamber 80 having a port 81 opening into the vacuum chamber 23 and defining a valve seat 84 in the valve chamber 80. A sealing flap 82 of resilient plastics material, such as Mylar (Trade Mark), is attached at one side of the chamber 80 to the valve housing and is adapted to form an imperfect seal with the valve seat 84. The flap 82 is biassed open by a second flap 83 of resilient plastics material, such as Mylar, similarly attached to the valve housing and with its free end engaging in a slot in the sealing flap 82. The spring flap 83 also serves to damp movement of the sealing flap 82. In operation (when the vacuum system is switched on), the sealing flap 82 is normally closed by the air pressure differential Ap/Vp between the vacuum chamber 23 which has a negative pressure Vp and the valve chamber 80 (Figure 4) which is at atmospheric pressure, but when the ports 25 are closed by a sheet S arriving thereover as shown in Figure 5, the leakage between the vacuum chamber 23 and the valve chamber 80 equalises the pressures on opposite sides of the sealing flap 82 which is thus urged to its open position by the spring flap 83 (Figure 5).

At the front of the document tray is provided a pair of brushes 33 attached to the front face of the air knife 27. The brushes project down into the document path and the document to be fed to acquired and pulled down to pass beneath the bottom edge of the brushes. This procedure assists in preventing multi-feeding. Documents returning to the tray (as described below) are also prevented from premature acquisition (misfeed/multifeed) since the brush assemblies restrict them from sliding across the documents still in the tray and being acquired out of sequence by the vacuum transport 20.

The pre-platen transport T1 consists of a pair of nip rolls 34, 35, an inner sheet metal and outer plastic inversion guide 38, 39, and the vacuum take-away system described above.

The nip pair 34, 35 is formed by two driven polyurethane rollers 34 mounted on a drive shaft carried on the side frames and two Delrin (Trade Mark) AF idler rollers 35 mounted on a spring-loaded shaft carried by the outer guide 39. The outer guide is hinged off the side frames for jam access. The inversion guide is completed by a portion of inner guide 38 coacting with a fixed guide 10. A cover portion 37 is hinged for jam access.

A pair of polyurethane coated driven input rollers 17 nip with reaction rolls 17a to feed documents to the platen transport T2. The platen transport T2 comprises a single white, wide friction drive belt 16 entrained over input and output transport rollers 18. The document is transported across the platen 3 by the belt 16. Three gravity rolls 18a apply a nip between the belt 16 and platen 3 and maintain drive across the platen. Belt tensioning and replacement is achieved by adjustment of the roller 18 at the output end of the platen. There are also two tracking guide rollers (not shown), one either side of the belt 16.

The post-platen transport begins with a pair of driven polyurethane exit rollers 52 coacting with Delrin AF idlers 53. Inner and outer guides 40, 41 extend from the exit rollers 52, 53 and serve to invert the documents on their way back to the tray 21. The inner guide is a one-piece plate and the outer guide is formed by a sheet metal guide 41a leading to plastic guides formed by the main cover at 41b and the jam access cover 54 at 41c. A pair of spring-loaded Delrin AF nip rollers 42 are mounted into the access cover 54 and act again a driven pair of polyurethane coated nip rollers 43 which project through the inner guide.

An output switch 63 provides jam detection.

Assembly 44 carrying the registration cross-beam 48a includes a pair of driven nip rollers 46, 47 and a diverter 45. When the assembly 44 is in the position shown in solid lines or in any position between the marks B4 and 8", documents are guided into the nip of rollers 46, 47. When, however, the assembly 44 is moved to a position (shown in dotted lines) beyond the B4 adjustment, diverter 45 crosses the normal path and sends the documents over the assembly 44 along a path between diverter 45 and fixed cover portion 55. Such sheets are guided along this path with the aid of guide ribs 55a on the underside of the cover portion 55. This arrangement permits the recirculation of documents larger than the tray 21 as described fully in our copending application no. (our case R/81020) filed concurrently herewith.

For the 8" to B4 range the documents are accelerated prior to entering the tray in order to help restacking. The accelerated nip is formed by the rollers 46, 47. A pair of polyurethane coated rollers 46 are mounted on a driven shaft and two Derlin AF idlers 47 are mounted in the upper guide which forms the diverter 45. Between the rollers corrugation idlers are mounted on the driven and idler shafts to corrugate the document. The rollers 46 are driven by a separate motor mounted on the assembly.

Hinged cover portions 37 and 54 provide jam access to the document handler and the pre-platen guides are separable for the same purpose. The whole document handler is pivotally mounted on the copier so that it can be hinged about its rear edge away from the platen. This provides access to the platen and permits manual loading and unloading of documents.

The operation of the document handler will now be described. At the start of a copy run documents are loaded into the recirculating document handler input tray 21. The presence of one or more documents is detected by the input tray sensor 60.

Absence of a document at the input tray sensor 60 when the start print button on the copier is pressed will result in normal operation of the base machine, copies being produced by scanning the platen.

Prior to all copying in precollation, recirculating mode of optics are parked below the right-hand end of the platen. This mode provides for the circulation of sets of documents ranging from 8" × 10" to B4 in size, i.e. not larger than the tray 21. All documents in a set must be of the same size. A set of copies is made at each circulation of the documents and copying is done in constant velocity or moving document mode.

On pressing 'start print' (with a document present in the tray 21) the VCF fan motor is run up to speed before a document may be fed. The motor run up time is approximately 3 seconds or less. The flap valve 28 is deenergised (open) during this run up time.

The set counter is energised to place the set counter arm on top of the stack of documents. If the sensor 60 has sensed a document and the set counter sensor is interrupted immediately after pulsing the solenoid a jam is signalled.

The platen belt (16) drive and platen registration edge (19) hold-down solenoid 19a are energised continuously throughout the copy run unless a single document is stopped on the platen and scanned. Separation of a document from the stack is achieved by the open vacuum valve 28 causing a vacuum to be formed below the bottom document. This vacuum acts through the vacuum belt perforations pulling this document onto the belts 22.

The air knife 27 floats the remaining documents, if present. Following a suitable time for the lowest document to be completely sucked down into the belts 22 the vacuum transport clutch is energised, causing the belt to move, pulling the lowest document from under the stack.

The document lead edge interrupts the vacuum timing sensor 61 when the document has travelled 20mm. Interruption of the vacuum timing sensor starts timers which determine when the vacuum transport clutch is deenergised and vacuum valve 28 is closed. The valve 28 closes when the document overlies ports 25 and the valve 26 opens causing the document to be fed into the nip rolls 34, 35. The vacuum transport clutch is then deenergised.

When the document lead edge reaches a synchronising sensor 62 just ahead of the platen transport T2, the copy sheet transport system and the processor cycle are initiated.

Separation of documents continues until the last document in the set, when the set counter sensor is actuated. The set counter thus provides indication of the number of documents in the set. If more than one set has been selected by the operator and the set contains more than one document, the documents are recirculated, until the number of sets requested has been copied.

For sets having a small number of documents an interset delay may be necessary to permit the first document to arrive back in the input tray before it is recirculated. This delay may occur for example for 5 or less documents when documents up to A4 size are being copied, and 4 or less documents when B4 documents are being copied.

The document handler may also be operated in non-sorted stacks where each document is multiply copied by registration and scan during a single circulation.

Figures 6 to 9 show another embodiment of automatic valve 26 according to the invention in which the flap valve member is replaced by a valve member 82a comprising a disc of resilient plastics material having integral spring feet 83a, four being shown. The disc 82a, which is suitably made of Mylar, is best seen in Figure 7. The valve 26 is shown at rest (vacuum system inoperative) in Figure 6 with the valve member 82a biassed open by its integral feet 83a. When the vacuum system is switched on and no sheet is present, the pressure differential Ap/Vp between the valve chamber 80 and the vacuum chamber 23 causes the spring feet 83a to collapse and the valve member 82a to seat against the valve seat 84 forming an imperfect seal as shown in Figure 8. When, however, a sheet 5 arrives over the ports 25, the leakage between the vacuum and valve chambers 23, 80 equalises the pressure on opposite sides of the valve member 82a which is thus urged upwards by the spring feet 83a as shown in Figure 9.

CLAIMS

1. An automatic valve comprising a valve chamber having a first opening to the atmosphere and a second opening for connection to a source of reduced pressure and defining a valve seat in the valve chamber, characterised by a valve member adapted to seat against the valve seat so as to form an imperfect seal and biassed away from the valve seat, the arrangement being such that when a reduced pressure is applied through the second opening the valve member will seat against the valve seat if the first opening is unobstructed and be biassed to its open position due to leakage past the valve member when the second opening is obstructed.

2. An automatic valve according to claim 1, including a flat valve member secured at one end for movement into and out of engagement with the valve seat, and a spring flap secured at one end adjacent the sealing flap and having its free end connected to the sealing flap near the free end thereof.

3. An automatic valve according to claim 1 in which the valve member comprises a sheet of resilient material having integral collapsible feet.

4. An automatic valve according to claim 2 or 3 in which the valve member is made of plastics material.

5. A vacuum belt conveyor for sheets comprising one or more air-pervious conveyor belt and vacuum means including a plurality of vacuum ports for applying a negative pressure at the back of the belt to hold a sheet against the belt, characterised in that said vacuum means includes at least one valve connected between at least one of said ports and a source of negative pressure and adapted automatically to close only when said port is not obstructed and said negative pressure source is operating.

6. A vacuum belt conveyor according to claim 5, including said automatic valve according to any one of claims 1 to 4.

7. A vacuum belt conveyor according to claim 5 or 6, comprising one or more perforate belts extending across the support surface having a plurality of vacuum ports arranged at intervals along the length of the conveyor, wherein a plurality of said automatica valves re-associated with respective ports or groups of ports.

8. A vacuum belt conveyor according to claim 5, 6 or 7, comprising a sheet feeder for feeding sheets from the bottom of a stack of sheets and including a port or transverse row of ports arranged beneath the forward end of the stack is controlled by an externally operated valve for acquiring the bottom sheet in the stack, and a second port or row of ports controlled by a said automatic valve is arranged ahead of the stack to advance a sheet forwarded to its from the stack.

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